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CROP QUALITY.*

ONE of the principal objects of agricultural research has hitherto been the improvement of crop yield with a view to the production of as large crops as possible. During the past few years, however, rapid advances in the science of nutrition have emphasized the need for paying increasing attention to the question of crop quality. It is common knowledge that the composition of plants grown on different soil-types in the same climatic regions varies in both their organic and especially in their inorganic components, and that, in many cases, these variations are due to the presence or absence of certain elements in the soil. It is also known that both mineral and organic contents of plants and, therefore, their nutritive value, may be greatly altered by modifying manuring or cultural treatments. It has also been shown that certain human diseases, such as bone, skin, digestive and nervous disorders, have resulted from restricted diets, or from the consumption of plant and animal products produced on soils either deficient in certain elements or containing elements injurious to health. On the whole, however, the amount of information available in these several fields is still scanty and localized. The subject, nevertheless, is of very great importance since it bears closely on the health of the animal kingdom. Man and animals depend almost entirely upon plants for their existence, and it is essential that the plants which they consume should not only be of the highest quality but also meet their nutritional requirements. Thus, apart from increasing crop yields, much more will have to be done in future to maintain, and where possible, to raise the quality of our crops.

There are many factors which affect the quality of crops and their value as food. Up to the year 1840, it was believed that plants should be nourished by organic substances. Liebig's mineral theory of plant nutrition disposed of this belief and simplified the problems of soil and plant nutrition. It was felt that, provided the constituents indicated as inadequate or deficient by a chemical analysis of the soil be supplied to the soil in the form of inorganic salt, then all should be well.

* Based largely on Report by B. Viswa Nath, Imperial Agricultural Chemist (*Scient. Reports of the Imperial Agricultural Research Institute*, New Delhi, year ending 30th June, 1939, published 1940) and on presidential address by Dr. E. C. Auchter to the Agricultural Section of the American Association for the Advancement of Science (*Science*, 89 ; 421, 1939).

Subsequent investigations, however, have demonstrated that the problem is much more complex than this. For instance, studies by Viswa Nath and McCarrison (1) with wheat and millets in soil cultures in pots and in the field have revealed the existence of a cycle of growth factors in nature. They have shown that manurial and fertilizer applications are capable of reacting on plants, not only by increasing yields, but also by affecting the quality of the resulting seed. For example, seed raised on soils poor in organic matter and with artificial fertilisers gave an inferior crop to that raised with farmyard manure. Using the same grain as was used in the crop experiments, McCarrison observed that the nutritional value of the grain to rats varied in a similar manner, and he attributed the nutritional difference in the vitamin content of the grain. The observation that the same grain which had provided better nutritive value had also given better seedlings suggested that grain raised with organic manure is richer in vitamins and in some constituent that stimulated plant growth; and that the plant growth stimulant and the vitamin might be either the same or, at least, so inter-related that the stimulant enabled plant metabolism to proceed normally. Direct experiments carried out with produce obtained by manuring with brewery yeast in field plots and used in animal nutrition tests, and comparative experiments with farmyard manure extracts and yeast extracts, provided evidence of the function of mirco-organisms in the process, and of the existence of the chain or cycle or accessory food factors of organic nature. Although these results were confirmed by several workers, the existence and the necessity for accessory food factors in plant growth and development was debated, and the superiority of organic manures and their extracts in plant nutrition was attributed by several workers either to the influence of iron or to trace elements. The position was clarified at a meeting in 1937 of the Royal Society, when the existence of growth factors for the vegetable kingdom was recognised. *Nature* (2) in reporting the substance of the discussion stated that the case established in the nutrition of animals is equally established in the nutrition of the most diverse varieties of cells; namely, that all cells from the lowliest bacterium to the cells of the highest animals are enabled to carry out the series of reactions leading to the production of energy and growth by the help of other substances mostly of the nature of the vitamins of animal nutrition.

The brilliant work of Kogl which led to the isolation of *auxins*—the substances concerned with the growth of plants—in a crystalline form from urine, malt, yeast, liquid manure and farmyard manure has been a big step in advance. Auxins or phytohormones have been shown to play a definite rôle in many life processes of plants. Kogl (3) also recognised the existence of a cycle of growth factors in nature. The work of Thimman (4) and that of Link (5) indicates the rôle of micro-organisms as contributing factors for the stimulation and regulation of plant processes. Link (6) and several other workers have brought forward evidence in support of the statement that the beneficial effects of green manuring, dung, urine, compost and humus may be due to the hetero-auxin or similar substances produced by fermentation. Tallarico (7) carried out experiments which indicated that natural manures showed specific effects not exerted by artificial fertilisers, and generally that seeds from plants that are over-nourished during the growth period have less vitality than seeds from a poorer soil. He has further observed that seeds grown under arid conditions possess greater germinating power and more vitality than seeds grown under humid conditions. Thompson (8) has drawn attention to the influence of fertiliser treatment and time of ripening on the germination of lettuce seed. Beauchamp and Lazo (9), discussing the relation between vigour of seed and nutritive elements in sugar-cane setts, have stated that, in the case of two months old ratoon-cane shoots, the vigour of the "*seed*" appeared to depend on reserve nutrients.

Many other examples could be quoted of work showing that plants require accessory food factors similar to vitamins for proper development and reproduction, and that soil conditions and the nature of manures available for the nutrition of the plant modify its composition and its nutritive value. On the other hand, results are also available that show that manures have no influence either on the course of plant metabolism or in regard to the nature, composition, digestibility, nutritive value or other physiological activity of the plant products. In view of this conflicting evidence, it will be obvious that much more research will have to be carried out before definite proof is established of the part played by each of the many complex factors which govern crop quality. It has been suggested that one of the most fundamental steps would be a thorough study of soils from the standpoint of their suitability or unsuitability for the production of certain crops. There is need, too, for an attempt to correlate the composition of foods with soil-type, climatic conditions, and the practiees followed in their production. Finally, investigations should also include thorough studies of proteins, amino-acids, carbohydrates, fats, vitamins, enzymes, hormones, and other growth accessory substances, the ordinary minerals, and the so-called "trace" or "rare" elements, and their effects upon man and animals.

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(1) *Mem. Dep. Agr. Ind. Chem.*, Series 9; 85, 1927 and *Ind. Jour. Med. Res.* 14; 351, 1926.
(2) Vol. 140; 161, 1937.
(3) *Chem. Ind.*, 57; 49, 1937.
(4) *Jr. Gen. Phys.*, 18; 23, 1934.
(5) *Bot. Gaz.*, 98; 816, 1937.
(6) *Nature*, 140; 507, 1937.
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(9) *I.S.J.*, 41; 70, 1939.

COMPOSTS AND TEA.*

[We publish below an abridged version of an address by Dr. K. B. W. Jones, PH.D., B. SC., lately of the Upasi Tea Experimental Station, Nellakotta, South India, which was given to the Nilgiris' Planters Association and published in The Nyasaland Tea Association Quarterly Journal, 2, No. 1, 1937, ED.]

THE Tea Scientific Department has taken up a definite position in regard to composts. While fully appreciating the value of composts in many branches of agriculture, it is of opinion that the particular conditions governing tea in South India greatly reduce their expediency. So much attention has been paid to the practical side of compost making that the question of whether composts are necessary or desirable has often been overlooked. The Department thinks that composts are often unnecessary, and that even where they are desirable, green manuring might prove a more suitable alternative. The reasons for adopting these conclusions are given in this article.

Composts serve two purposes in agriculture: they supply the soil with humus, and also with plant-food in an advantageous form. Humus is necessary in order to keep a soil in good tilth; it improves the physical condition of the soil, it promotes better aeration, and it helps the soil to maintain a desirable amount of water. It is also responsible for much of the bacteriological activity which controls the availability of plant-foods, and it is particularly closely linked with the natural nitrogen supply in the soil.

Humus is produced by the decomposition of organic matter by a sequence of micro-organisms. In the process of degradation, the carbohydrates in the plant residues tend to be eliminated as carbon dioxide and water, but the nitrogen from the proteins tends to be retained by micro-organisms. As a result, there is a tendency for the ratio of carbon to nitrogen in the organic matter to diminish until it approaches 10 : 1, when different types of bacterial life appear to reach a point of equilibrium. Where carbohydrates are present in excess, the organisms engaged in breaking them down tend to draw on the existing reserves of nitrogen in the soil for their own use, and this results in a temporary lack of nitrogen available for use by plants. As the carbon-nitrogen ratio approaches 10 : 1, conditions become suitable for the liberation of increasing quantities of nitrate-nitrogen, which is now available for plants. At the stage when the carbon-nitrogen ratio approaches 10 : 1, the organic matter has mainly been converted into humus.

In most agricultural industries where a crop is removed from the soil and is therefore not available as a raw material to maintain the supply of humus during the following year, the humus content of the soil is regulated by fallowing, the application of farm-yard manure, by ploughing in a catch crop (which is equivalent to green manuring), or by applying composts. In many tropical agricultural industries, green manuring has been greatly recommended, but under certain conditions the results have been unsatisfactory, for example where the annual rainfall was less than about 20 inches per annum, or where the time of incorporating the green manure was close to the time of sowing an annual crop. In the latter case, the preliminary drain on the soil for available nitrogen caused temporary starvation of the young plants and resulted in diminished crops. Under such circumstances, it was found profitable to compost the green material available, together with any other available waste organic matter, and to apply the compost to the soil whenever convenient. Composts derived from green manures and waste materials provide not only humus but additional quantities of nitrogen, phosphate and potash.

Green manures grown on the site to be green-manured, cause a slight increase in the amount of fixed nitrogen present in the soil, but do not contribute at all to the total amount of phosphate and potash. Compost, on the other hand, provides a means of adding nitrogen, phosphate and potash from external sources, which thus contribute to the richness of the cultivated land. It was on the basis of these undisputed facts that composts have recently been brought to the notice of agricultural interests.

The fundamental claim made for composts is that they provide humus and plant-foods. This is undeniably true, but, before accepting composting as an important development in tea-culture, it is necessary to consider several other questions; and more particularly the following:—

(*a*) Does tea in South India require to be supplied with humus and plant-food?

(*b*) How much humus and plant-food does compost supply?

(*c*) Is compost the most profitable method of supplying this humus and plant-food?

By far the greater part of the tea in South India is well shaded, and the droppings and loppings from the shade trees are effective in keeping the humus content of the soil at a high level. The value of shade is closely related to its function in supplying humus, but shade is also particularly necessary in South India owing to the distribution of rainfall and the length of the pruning cycle. From the humus standpoint, compost only adds more of what is already existent in sufficient quantity. It might be logical to reduce shade and to employ compost instead, but to employ both together seems unnecessary. Where there is little or no shade, or where clean weeding is practised, compost may profitably be utilised to maintain the humus content of the soil.

The chief plant-foods required by tea are nitrogen, phosphate and potash. The removal of a crop results in the impoverishment of the soil in phosphate and potash but the nitrogen is usually replaced naturally by specialised bacteria. The plucking of tea thus removes phosphate and potash but does not greatly affect the nitrogen content of the soil. Strangely enough, manuring

trials almost invariably indicate a strong response to nitrogen manuring with very little response to either phosphate or potash, although the reserves of phosphate are apparently not great in many South Indian tea soils.

In view of restriction, extra crop is not particularly desirable. On many estates, it is already difficult enough to reduce the crop to the required limits. Hence, the increase in crop accompanying the addition of compost is not likely to be generally desirable under present conditions. It may be claimed that compost is only applied to renovate the humus supply in the soil, and not as a fertiliser. But the two functions of compost are inseparable, and therefore compost acts as a fertiliser whether it is applied as one or not.

It has been suggested that composts improve the quality of tea. The arguments in favour of this contention are not convincing. Manuring experiments on tea have failed to show any benefit from organic manures as compared with inorganic manures, nor have nitrogen, phosphate, or potash been shown to improve or destroy quality. Occasionally, suggestive results have been obtained in one direction or the other, but it has not been possible to show that these were not due to chance. It is also sometimes claimed that, because excessive humus is beneficial to the quality of garden produce, it must be good for the quality of tea. This is a fallacy, because an attribute which is called quality in one product may be undesirable in another. Tea is not prized for the size of its blooms, nor for early fruiting, nor for its vitamin content. It is possible that composts would improve quality if they were used to stimulate growth, so that equal crop might be obtained by finer plucking. Their use in this way is justifiable if the extra expense involved might be relied on to give a commensurate increase in price. The employment of composts, therefore, may be justified on fields which are going back as a result of lack of humus, or in order to carry out finer plucking without loss of crop.

How much humus and plant-food does compost supply? The answer to this question depends on how the compost is made, and whence the raw material is derived. If the raw material is derived from the tea-fields, the compost contributes very little new or extra plant-food to the soil. Apart from the amount of humus, nitrogen, phosphate and potash contributed by the cattle-manure and wood-ashes, the compost contributes nothing, but it will still exert a slight effect because it concentrates these plant-foods both in time and place. Whereas the natural decomposition of falling leaves, &c., would give rise to a slow and possibly erratic supply of available nitrogen, phosphate and potash, the composting process will have cut off this supply almost completely for a time, but the application of the finished compost later puts back the accumulated products suddenly and all in one spot. Instead of a regular maintenance of the supply of humus and available plant-food, a deficiency is created by the removal of raw material, and then, after three months or more, this deficiency is suddenly made good. It seems very doubtful whether this process is worth a large expenditure per acre, but it can only be tested by carefully regulated experiment. This procedure in compost making may be of practical help when employed to boost poor fields at the expense of the richer ones, but where practicable, it would certainly be preferable to use raw material from uncultivated areas.

A good average compost applied at the rate of 5 tons per acre contributes about 55 lbs. nitrogen, 25 lbs. phosphate and 50 lbs. potash per acre, but these figures are liable to wide variation. A difficulty is encountered when a nitrogen-rich compost is available. If it is required to supplement the humus content of a soil, it is necessary to use a large quantity of compost, but this may contain so much nitrogen that it will have a forcing effect, which may be most undesirable. Our usual recommendation where rich composts of this type are employed is to reduce the quantity applied per acre, unless a greatly increased crop can be viewed with equanimity, and in the making of future composts, to use more twiggy or less nitrogenous raw material.

Is compost the most profitable way of supplying humus and plant-food? On well-shaded estates, the humus supply is naturally easily maintained. The cost of this humus supply is not readily assessed, since the cost of establishment and maintenance of shade, and the means adopted for incorporating leaf-fall, are not chargeable entirely to the humus account. Shade and cultivation are useful and necessary for other reasons than the supply of humus. There is no doubt that humus obtained in this way is much cheaper than humus derived by composting, but there are no definite figures by which to prove this contention. Where shade is lacking and humus must be supplied, this may be done by applying compost, or by the use of green manuring. Cheap composts are usually obtained by special organisation in order to reduce the cost of collecting the raw materials. It would be possible to apply the ingenuity displayed in this way to the cheap collection of green material in or around the fields requiring compost. By growing green manures on all available sites, and by augmenting supplies obtained in this way by weed growth and jungle loppings, raw green material with quite a low carbon-nitrogen ratio could be collected in reasonably large quantities and applied in the field whenever labour is available. The cost of collecting material need not be greater, and thus the cost of transport of compost to the field is eliminated. Distribution and application in the field would possibly be slightly more expensive, but the result would be an improvement in the humus content of the soil without such a sudden forcing effect due to the nitrogen applied. The relative merit of the two methods is largely one of cost and convenience in practice, and no definite statement on the subject can be made, except that theory would lead one to expect the results of green manuring to be more suitable to tea than composting. As regards the supply of plant-foods (*i.e.*, the use of composts as

fertilisers), composts certainly provide plant-food cheaply, but an equivalent result can be obtained by green manuring. By contrast with artificials, composts made and applied cheaply may provide more nitrogen, phosphate and potash than can be supplied at the same cost by artificial fertilisers, but, by using artificials, it is possible to control the amount of each supplied and excess can be avoided. The practical significance of chemical analytical data obtained, and the deductions which can be made from them in the case of composts are discussed below

Moisture Content:—A good compost should contain between 40 per cent. and 50 per cent. of water. This is a tribute to the valuable water-retaining capacity of humus. If the humus content is satisfactory, a compost will retain about 40 per cent. of water without appearing wet. If the moisture content is over 50 per cent., it suggests the compost is too wet, and if 5 tons of compost with 60 per cent. of moisture are applied, the effect is the same as that of 4 tons of the same compost with only 50 per cent. moisture. The cost of transport of the extra ton of water is pure waste. Where the moisture content is lower than say 40 per cent., it is usual to find the compost unsatisfactory in other respects. The cause may be that the compost has not been adequately watered, or the humus content is too low. It was found, however, that composts with a high water content are on the whole richer than those with too little, so that in general it is preferable to keep the compost well watered than to stint the water. It is desirable in practice to avoid under-watering during the first two months of manufacture, and to avoid over-watering during the last month, particularly just before the compost is applied.

Humus:—Humus is not estimated directly in the laboratory, but its amount is judged by the observed figures for carbon and nitrogen. A good compost should give a loss on ignition equivalent to about 13 per cent. of the original weight of the compost, and the carbon-nitrogen ratio should be less than 12 : 1. The percentage nitrogen should be about 0.45 per cent. and the carbon content between 4.5 per cent. and 6.0 per cent. If the nitrogen content is high, it is probable that the raw material used was too rich in nitrogen, and therefore had a low carbon-nitrogen ratio originally. Since the purpose of composting is to reduce a high carbon-nitrogen ratio, it is evident that little good has been done by composting, and the material used might equally well have been applied in its original state. Where rich raw materials are used, there is a tendency for nitrogen to be wasted during manufacture, and it is desirable to mix this rich material with poorer material. The use of leafy green manure by itself does not make a better compost than a mixture of this green manure with straw, *Grevillea* leaves, *Lantana* or grass. It is therefore likely that the quantity of compost obtained may be increased by using poor quality raw material with the good. This is one of the most attractive features of compost making.

It is sometimes found that the carbon-nitrogen ratio is below 10 : 1; in this case the raw material was probably purely green manure and no useful purpose was served by composting. More frequently the carbon-nitrogen ratio is high. This is a clear sign that decomposition has not gone far enough, but no clue is available by which to decide the cause. This should not occur if either the Indore method or the Fowler method has been followed out correctly, and is usually due to some practical short-cut having disturbed the process. Theoretically speaking, such composts are comparative failures, since the primary object of compost manufacture has not been fulfilled. To avoid such occurrences, it is desirable to keep a close watch on the temperature of the heaps during the early part of their history. If the temperature does not rise until a testing iron becomes almost too hot to hold, the process is not going well, and a product with a high carbon-nitrogen ratio is likely to result. Attention should be paid to see that the heap is moist but not moist enough for water to leak out. The heap should also be protected from wind, but should not be so tightly packed or well shielded that no air can penetrate it. Composts made in heaps exposed to the monsoon are very apt to suffer in these ways. It is also possible that the dose of cattle manure was inadequate to start the decomposition sufficiently rapidly. Neglect of the addition of urine—earth or wood-ash may be a contributory cause, but these are not likely to be omitted accidentally, and hence their omission would obviously be immediately suspected as a probable disturbing influence.

A good compost does not contain more than about 25 per cent. of material insoluble in acid after ignition. This material is derived mainly from the urine—earth and from soil adhering to the raw material used. The latter is of more importance than one would expect, because, as the organic matter rots, it loses weight while the amount of earth becomes an increasing percentage of the whole bulk. This is particularly the case where refractory material is used and the loss of weight is especially large.

The phosphate and potash contents of a compost are very subject to fluctuation and cannot be closely controlled. The greater the amount the better, but no undue importance is attached to this.

It is strongly recommended that composts should be applied to poor areas and not to good areas where their best qualities are more likely to be wasted. It is tempting to distribute the compost in the fields nearest the chosen convenient site for its manufacture. At the risk of increased costs, it is better to make compost near the poor areas, or to pay for the extra transport of the compost to such spots. Compost should not be applied as a top dressing. Either it should be distributed in pits or it should be forked in. If applied only superficially, there will be a tendency for the roots of the plant to rise too much to the surface where they will be adversely affected by the following dry weather.

OBSERVATIONS ON THE PARASITISM OF *ROSELLINIA PEPO* PAT.

By J. M. Waterston.
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I.—Introduction.

Some of the most important root diseases of perennial crop plants in the West Indies are caused by fungi belonging to the genus *Rosellinia*. Tradition associates these diseases with shaded soil, rich in decaying matter, through which the fungi spread by means of mycelial fans. These are long strands made up of a number of longitudinally arranged hyphae which penetrate either the collar or the root of the host and also spread freely through the soil and over the substratum and bring about infection of other neighbouring plants. The serious nature of the diseases produced depends largely on this character, since under suitable environmental conditions, distribution by means of the mycelial strands is rapid.

The areas affected with *Rosellinia* vary between two environmental extremes (Figs. 3 and 4). The first consists of regions of unrestricted spread, where conditions of high rainfall and lack of sunshine due to dense shade encourage humus formation. Under these conditions the fungus attack is in the nature of an advancing sheet. The fungus in this phase may not only derive its food saprophytically from decaying leaf mould but appears to behave as a dangerous although incidental parasite to the stems and roots of trees and shrubs encountered during the course of its advance. These conditions exist in some of the wetter areas as in Dominica where root diseases caused by *Rosellinia* spp. may act as limiting factors to lime production. In cases like these, the conditions which best suit the host plant, best suit the fungus also, with the result recorded by Fawcett (6), Nowell (22) and Stell (28) that the finest trees are most liable to attack and are most frequently killed.

The second region which may be recognised is one of slow and restricted spread, found where rainfall is lighter, with little accumulation of humus or surface litter and where shade trees may be absent [South (27), Stockdale (29) and Briton-Jones (5)]. Under these conditions the spread of the fungus is confined to root contacts or from fragments of wood or root stumps of susceptible hosts which have been aptly described by Gadd (10) as "food bases". A typically infested area consists of an open patch representing a loss of anything between 20 to over 100 trees, with some standing dead or dying at the margin. Most of the cacao estates in the West Indies have a field in which will be found one or more such *Rosellinia* patches, where the activities of the fungus appear restricted to a small area.

The present investigation was undertaken by the writer (34) at the suggestion of the late Dr. Briton-Jones with the object of determining whether the limitation of the disease to these patches could be correlated with the existence of any predisposing soil factors and whether the fungus was functioning as a facultative parasite under a range of environmental conditions limited to that area.

Species of *Rosellinia* involved in the Caribbean.

We owe most of our knowledge of *Rosellinia* root disease in the Caribbean area to the work of Nowell (22, 23, 24) who recognised three species involved ; *R. bunodes* B. et Br., *R. Pepo* Pat., and *R. paraguayensis* Starb. The last species has been recorded only by Nowell as a parasite of cacao in Grenada. The writer had an opportunity of collecting the same species at Annandale, Grenada, at an elevation of 1,200 feet in a region with an annual rainfall of over 200 inches. Perithecia were found abundantly on a wound left by a badly pruned branch of a cacao tree about 4 feet from the ground. The tree was otherwise healthy, no penetration of living tissue being observed. On the same hill-side contour not far distant from this station under identical environmental conditions with those in which *R. paraguayensis* was acting as a saprophyte, *R. Pepo* was found in the mycelial stage as a root parasite of cacao. The latter species has been solely and consistently isolated from the roots of cacao and nutmeg affected by *Rosellinia* disease both in Trinidad and Grenada by the writer who has not been able to confirm Nowell's suggestion that *R. paraguayensis* may play a similar rôle. It may be noted in this connection that Briton-Jones (5) held the view that in the British West Indies the species of *Rosellinia* which establish themselves on tree stumps and assist in their disintegration do not belong to the parasitic group.

The two important species of *Rosellinia* causing root disease in the West Indies appear to be confined to *R. bunodes* and *R. Pepo*. Prior to the work of Nowell they were often confused with one another, and even to-day insufficient care is taken by some observers to distinguish the two species in the field. Due allowance however must be made for the difficulty in determining the identity of species of *Rosellinia* on some hosts by mycelial characters alone, and in the absence of the perfect stage, unless means exist for checking material with cultures maintained in the laboratory. The writer in common with previous investigators was unable to find the perfect stage of *R. Pepo* on cacao or nutmeg although carefully sought in Trinidad and Grenada. Perithecia of *R. bunodes* on the other hand were readily found in Grenada on roots of *Hibiscus rosa-sinensis* and Grapefruit, *Citrus paradisii*. It would appear that

a rarely produced perithecial stage is a specific character of *R. Pepo* and this coupled with its parasitic tendencies should serve to distinguish it from *R. paraguayensis*. The characters distinguishing *R. Pepo* from *R. bunodes* are compared in Table I.

Susceptibility of Host Plants.

In respect to susceptibility of host plants, *R. Pepo* has a more restricted range and geographical distribution than *R. bunodes*. Nowell (24) records the number as limited. Certain species are highly susceptible and when used as shade trees to plantation crops they often act as centres for the formation of *Rosellinia* patches. These include Avocado, *Persea gratissima ;* Breadfruit, *Artocarpus communis ;* Jak, *A. integer ;* Immortelle, *Erythrina* spp. ; and Pois-doux, *Inga laurina*. The chief host of economic importance attacked by *R. Pepo* is Cacao, *Theobroma cacao*. Others are Nutmeg, *Myristica fragrans ;* Limes, *Citrus aurantiifolia ;* and Coffee, *Coffea* spp. The following have also been reported susceptible: Pigeon Pea, *Cajanus indicus ; Cassia fistula ;* Horse Bean, *Canavalia* sp. ; Dasheen, *Colocasia antiquorum ;* West Indian Locust, *Hymenaea Courbaril ;* Cassava, *Manihot utilissima ;* and Banana, *Musa sapientum*. Plants exhibiting a high degree of resistance to both species of *Rosellinia* are Guinea grass, *Panicum maximum ;* Mango, *Mangifera indica ;* Sugar cane, *Saccharum officinarum ;* and (?) Sour Orange, *Citrus Aurantium ;* whilst the following appear to be immune: *Adiantum* sp. ; Coconut, *Cocos nucifera ; Glyricidia maculata* and *Tradescantia* sp.

Ferrer (7) records a resistant variety of cacao named Pajarito in Colombia but does not state the species of *Rosellinia* involved. The writer whilst in Grenada observed two cases of apparent immunity of cacao towards *R. bunodes*. The first case was a hedge of *Hibiscus rosa-sinensis* on Petit Etang Estate where an annual rainfall of 100–120 inches is experienced. The hedge attacked by *R. bunodes* at one place passed a cacao tree the roots of which grew directly underneath. No infection was found on the cacao roots although surrounded by diseased *Hibiscus* roots thickly covered with perithecia of the fungus. The other case was on the same estate where perithecia

Table I.

Characters distinguishing *Rosellinia Pepo* from *R. bunodes*.

Appearance of Mycelium.	*R. Pepo.*	*R. bunodes.*
I. *On Host* :—(*a*) *External*		
(i) at collar above ground	Broad fan encircling stem. Light grey margin shading to brown or purplish-black with an olive-green tint.	Encircling sheet cream white at first, later turning purplish-black.
(ii) on root surface below ground	Irregular coating of loose cobweb-like strands, at first smoky grey, later turning black and coalescing into a carbonaceous mass with a woolly or glossy felt-like surface.	Closely applied, firm textured, black, branching strands which thicken into irregular knots along their course.
(*b*) *Internal*		
(i) in cortex ...	Cortical strands white, irregular in shape.	Cortical strands cylindrical with a black periphery and a white core.
(ii) at junction of cortex and wood	White fans or star-like webs.	Black, thread-like strands running irregularly over surface of wood.
(iii) within wood ...	Colourless, later forms thin plates which appear in cross section as black zig-zag lines. No strands formed.	Colourless, later forming black strands.
(iv) within herbaceous stems	Firm, round, buff coloured strands with a white centre.	Round black strands.
II. *In Culture.*		
2 % Malt Agar ...	Growth dark brown and glossy at first, later woolly and olive-green. Mycelial strands white turning black with age.	Growth white and woolly at first, later turning buff coloured. Mycelial strands black.

of *R. bunodes* were again obtained from the base of a 5-year-old grapefruit tree which had been dead for one year. This was surrounded by two cacao trees and one cacao stump, none of which revealed any trace of the fungus. The apparent immunity of cacao in these two cases might possibly result from *R. bunodes* showing a preference for *Citrus* and *Hibiscus*. However these observations confirm those of Nowell (24) who failed to find this species on cacao although he mentions a case recorded by South on young plants growing near diseased arrowroot.

II.—Field Observations.

Field observations on root disease were carried out on different estates in Trinidad and Grenada with the object of obtaining information regarding soil conditions and the incidence of *Rosellinia* attack on cacao. Detailed soil analysis was performed by the Department of Chemistry of the Imperial College of Tropical Agriculture through the kindness of Prof. Hardy. The methods used are recorded in a paper by McDonald *et al.* (19). Selected examples are given below.

TRINIDAD: RIVER ESTATE.

A diseased patch of cacao situated in Field 20b, in a flat area of alluvial silt, with an annual rainfall of 60–70 inches was selected for special study. The field was 35 years old and the diseased patch, which affected some 143 trees, 28 years old (Fig. 3). Shade trees were absent. Control measures adopted had been restricted to uprooting diseased trees and burning them. Three distinct areas could be recognised within the patch (Fig. 1) roughly defined by two isolation trenches: (A) a central area where the infection originated surrounded by the first isolation trench which had failed to prevent the spread of the fungus to adjoining trees. There were no original trees left in this area but 21 out of 34 supplies were over 6 years old, suggesting that the area was recovering from the onslaught by *Rosellinia Pepo*. No evidence could be found of the presence of the fungus in an active state in this region: (B) an annular area formed between the first isolation trench and one constructed at a later date. In this region a high proportion of the supplies between the ages of 1 to 3 years were in an unthrifty condition and the fungus in various stages of active parasitism was observed attacking many. Bananas, dasheen and sugar cane growing in this region were not observed affected: (C) the outer area beyond the second isolation trench comprised the rest of the field of original trees, all of which were healthy save two in the first adjacent row.

Bulk soil samples were taken by means of auger borings from seven randomized sites in each of the three areas. Four sampling depths were taken, three, six, twelve and twenty-four inches being considered sufficient as the majority of the cacao feeding roots occur within these extremes. The mycelial fans of *R. Pepo* were found within six inches to one foot below the surface but always originating from a portion of infected root. The mycelium was also observed in earthworm burrows in a similar manner to that described by Nattrass (20) in the case of *R. necatrix*. The results obtained are given in Table II.

Soil Texture. The analysis shows definite evidence that the area where the disease originated is more sandy with the soil becoming stiffer as the healthy area is approached.

Hydrogen Ion Concentration. The disease has spread from a more alkaline to an acidic area.

Nitrogen and Organic Matter. There are no significant differences in organic matter content or in total nitrogen in the three areas, nor are there any definite trends in the C/N ratio.

Available Phosphate and Potash. In the area of origin and recovery from the disease (A) the amounts of available phosphate and potash are adequate. Phosphate deficiency is higher in the healthy area (C) and is very low indeed in the annular area (B). The same is true for potash.

Rate of Nitrification. The rate of nitrification is very much slower in the annular area, the available nitrogen being reduced owing to increased exposure of the soil caused by the death of the original trees.

Discussion.

One of the interesting features apparent from an examination of the above data is the existence of *R. Pepo* in soil of such a low level of fertility as that exhibited in the annular area (B). Most observers usually associate *Rosellinia* root disease with areas rich in organic matter but it will be noted that the organic matter content is not significantly higher in the diseased than in the area free from infestation.

Brief comment may be made on the "wave of life" of the fungus. It was observed that the centre of origin of the diseased area (A) became also the area of recovery. As the supplies were between 7 to 8 years old it had taken nearly 10 years of supplying to re-establish the crop. South (26) has recorded *R. bunodes* to be even more persistent, the fungus remaining in fallow land for 25 years to reappear with the establishment of a plantation crop. Reference to the diagram emphasises the futility of constructing isolation trenches which are merely circumambulatory, since these fail entirely to stop the spread of the fungus.

(2) LA VEGA ESTATE.

A diseased patch of cacao investigated in Goodwa Field at the above estate in the Montserrat District was of unusual topographical interest. The area, on Brasso Sand soil with an annual rainfall of 98 inches, was situated on a miniature plateau on a hill slope near to a ravine. The diseased patch did not involve more than one

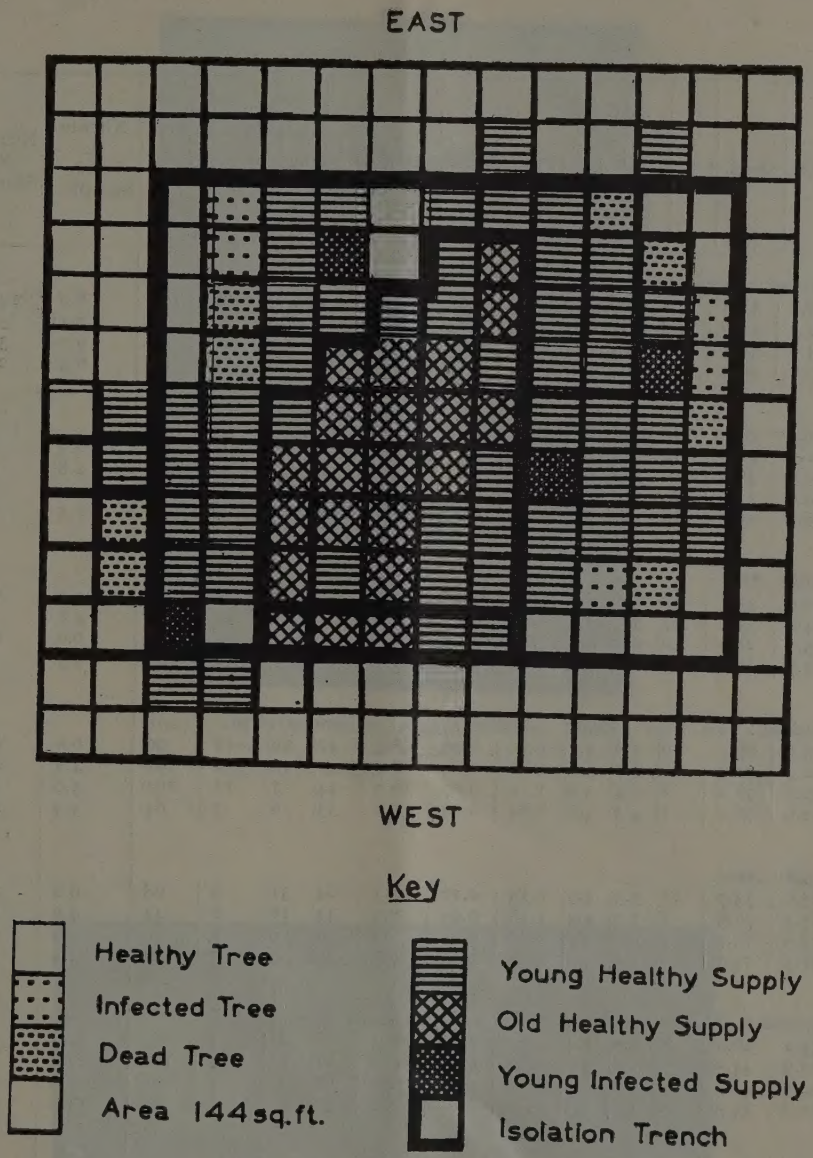

FIG. 1.—Diagram showing incidence of *R. Pepo* in diseased patch of cacao, River Estate.

dozen trees and had not spread any further in extent during the 20 years in which it had been under observation by the planter. The result of analysis of soil samples taken from the diseased area D, and compared with an adjacent area E, which was free from infection is shown in Table II.

Soil Texture. Both samples are very sandy and there is nothing to choose between the two.

Hydrogen Ion Concentration. Both samples are very acid, the diseased area very much more so than the healthy, being too low for the normal production of cacao.

Nitrogen and Organic Matter. The organic matter is much lower in the diseased area than in the healthy. The C/N ratio is lower in the diseased area and unfavourable for normal cacao production.

Available Potash and Phosphate. The available phosphate is low in both samples and is very deficient. The available potash is also low in both but is 30 per cent. higher in the diseased area.

Rate of Nitrification. The available nitrogen is about the same for both samples.

Table II.

ANALYSIS OF SOIL FROM *Rosellinia* PATCHES.

No.	M.P.S.	Sand. %	I.T.	pH. Normal.	pH. Exchange.	O.M. %	Total N. %	C/N.	Available Nutrient.	Rate of Solution.	Available P_2O_5 p.p.m.	Available K_2O p.p.m.	Nitrate N. Fresh Sample.	Nitrate N. Stored.	Nitrate N. Stored $+(NH_4)_2SO_4$.
A Trinidad: River Estate: Field 20b. Area of Origin and recovery.															
3″	38.1	51.0	28	6.4	6.0	3.63	0.22	9.7	103	42	38	105	8.9	146.0	789.0
6″	34.3	52.0	24	6.2	5.7	2.30	0.15	8.6	90	23	21	85	7.4	39.0	251.0
12″	33.8	51.5	24	5.9	5.0	1.59	0.12	7.9	38	15	32	81	9.0	33.0	197.0
24″	27.6	56.5	16	6.1	5.4	0.65	0.06	6.1	41	9	8	67	6.5	27.0	38.0
B Annular Area of Fungal Activity.															
3″	42.3	40.0	34	6.0	5.3	3.44	0.17	12.0	52	24	6	28	6.3	7.4	32.0
6″	40.6	38.0	33	5.7	4.7	2.27	0.14	9.2	31	30	6	46	2.8	9.6	42.9
12″	40.6	32.0	34	5.3	4.3	1.82	0.12	8.8	26	4	6	55	3.0	8.5	28.7
24″	26.9	56.5	14	5.6	5.0	0.35	0.03	6.9	22	4	4	27	2.5	6.2	2.1
C Healthy Area.															
3″	46.0	35.1	39	5.6	5.0	3.38	0.20	9.8	65	22	17	81	3.9	31.6	37.1
6″	44.1	35.5	37	5.1	4.3	2.01	0.16	7.3	75	30	12	56	4.8	9.7	11.4
12″	45.4	25.0	40	5.0	4.2	1.30	0.11	6.9	97	14	9	58	6.0	10.7	16.8
24″	31.7	45.0	23	6.3	5.8	0.63	0.07	5.3	58	1	6	29	5.5	5.7	17.4
D Trinidad: La Vega Estate: Goodwa Field. Diseased Area.															
3″	23.1	69.7	9	4.9	4.2	1.33	0.09	8.5	47	16	8	90	6.6	22.4	28.6
6″	22.4	72.2	8	4.7	4.0	0.88	0.06	8.2	41	12	9	92	4.4	18.7	11.7
12″	22.3	78.2	8	4.4	3.9	1.22	0.07	10.0	44	7	11	101	5.9	13.7	11.5
24″	22.6	78.0	7	4.3	4.0	0.64	0.04	9.2	33	6	7	84	5.3	11.9	7.8
E Healthy Area.															
3″	25.6	73.7	11	5.5	4.9	2.15	0.12	10.3	64	31	6	68	6.2	25.2	89.5
6″	23.3	77.5	8	5.3	4.4	1.38	0.09	8.9	44	18	8	44	4.6	16.5	23.2
12″	22.5	75.7	7	4.6	4.0	0.93	0.07	7.3	41	9	8	76	5.9	14.0	4.3
24″	21.3	74.7	6	4.6	4.0	0.53	0.05	6.6	46	5	5	74	4.4	13.2	2.9
F Trinidad: Montana Estate: Field 2. Diseased Area.															
3″	34.1	46.0	25	6.0	5.4	4.57	0.26	10.3	68	44	4	141	12.5	49.2	147.7
6″	23.3	44.5	25	5.6	5.0	3.24	0.21	9.0	81	63	4	118	13.2	33.0	108.6
12″	22.5	42.0	22	6.2	5.3	1.10	0.10	6.3	76	18	4	83	4.9	18.7	14.6
24″	21.3	44.5	20	5.8	4.5	0.59	0.07	5.0	31	7	4	62	4.5	15.7	10.1
G Trinidad: Henry Estate: McDougal Field. Diseased Area.															
3″	28.4	77.0	13	6.3	5.9	2.75	0.17	9.2	179	105	25	186	14.8	24.8	98.3
6″	25.3	81.0	9	5.9	5.2	1.54	0.11	7.9	77	36	12	113	19.1	17.5	46.3
12″	23.3	81.0	7	5.9	4.8	0.78	0.07	6.2	72	17	29	64	10.0	9.3	9.4
24″	22.1	82.5	6	5.4	4.3	0.50	0.04	8.3	56	14	21	46	12.0	11.6	5.2
H Grenada: Annandale Estate: Ross Field. Diseased Area.															
3″	63.0	30.0	57	6.6	6.2	15.87	0.53	17.3	243	262	29	535	24.6	67.4	78.4
6″	48.6	28.1	43	6.7	6.0	3.88	0.20	11.5	104	36	14	379	9.6	17.2	25.0
12″	51.0	17.5	47	5.9	5.5	3.22	0.19	10.1	73	38	9	313	0.9	9.9	6.8
24″	53.4	15.0	50	6.4	5.7	3.00	0.18	9.6	67	36	10	274	0.2	5.1	8.0
I Healthy Area.															
3″	51.0	33.6	44	6.1	6.1	7.74	0.31	14.3	—	—	32	715	34.0	49.2	82.1
6″	46.4	30.5	40	6.8	6.2	5.53	0.24	13.5	128	25	25	507	18.5	36.7	72.9
12″	38.4	41.6	30	7.4	6.8	3.00	0.13	13.8	85	42	17	337	17.1	27.5	32.8
24″	37.1	37.1	30	7.2	6.0	2.10	0.10	12.7	50	13	18	192	8.7	15.5	18.6

FIG. 3.—*R. Pepo* patch in cacao, River Estate Trinidad, on alluvial silt. No shade trees Rainfall 60 inches.

FIG. 4.—*R. Pepo* patch in cacao and nutmeg, Annandale Estate, Grenada. Rainfall 120 inches. Note ground provisions and bananas.

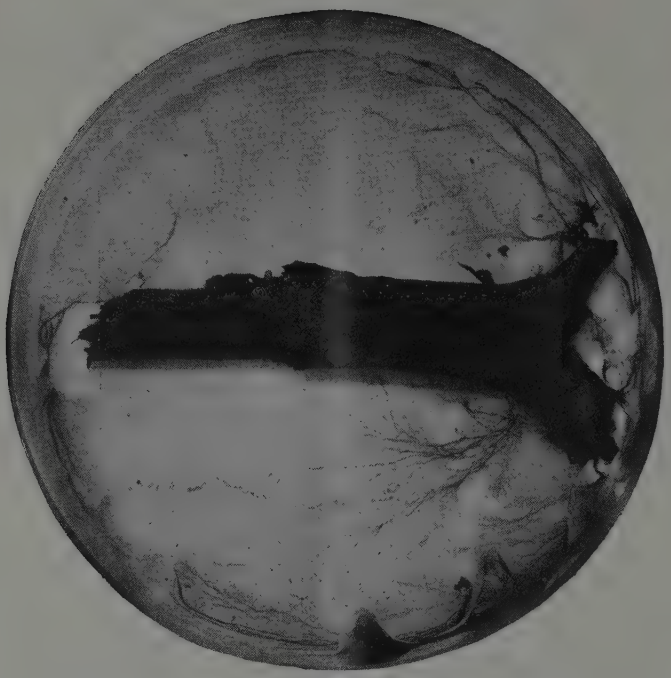

FIG. 5.—Mycelial fans of *R. Pepo* growing out from cacao root food base.

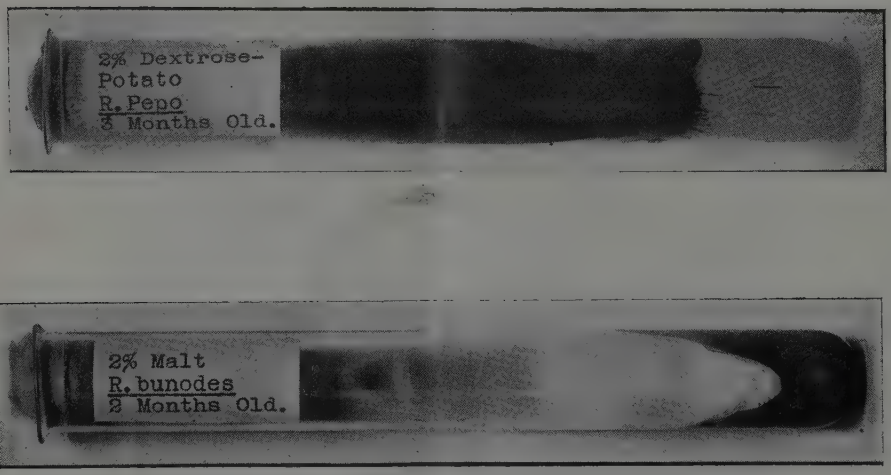

FIG. 6.—Production of rhizomorphic strands by *R. Pepo* and *R. bunodes* compared on carbohydrate media.

FIG. 7.—*R. Pepo* from cacao on 2 per cent. Malt Agar. Colour dark olive-green.

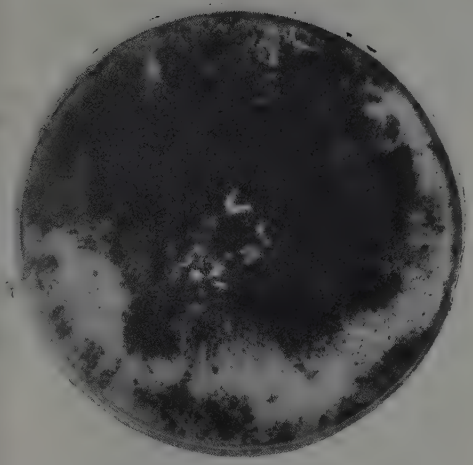

FIG. 8.—*R. bunodes* from Hibiscus on 2 per cent. Malt Agar. Colour white to dark buff.

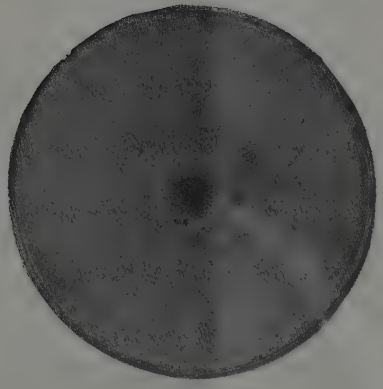

FIG. 9.—Showing method of inducing formation of coremia of *R. Pepo* on mixed media.

FIG. 10.—White strand formation by *R. Pepo* on sterilised cacao root.

FIG. 11.—"Black line" formation by *R. Pepo* in cotton wool plug.

FIG. 12.—Cacao seedlings growing under aseptic conditions on carbohydrate media. Seedlings in central flask killed by inoculation with *R. Pepo*. Controls on either side remained healthy.

Discussion.

One important fact would appear to emerge from the above analysis, namely that neither available phosphate nor potash are connected with the incidence of the disease. No one particular factor of those recorded can be selected to distinguish the diseased from the healthy area and it remains to consider the importance of topography and the water relationships of the soil. Although at first the impression might be obtained that the land in this area is well drained owing to the sandy nature of the soil, the writer feels that this might not be the case during the rainy season. Rain water will collect on the hill slope immediately above the plateau (Fig. 2) and in the absence of contour drains will collect on the projecting shelf of the hill-side. Thus will be obtained a condition analogous to that described by Briant (3) of a wet sub-soil on a hill-slope defining the limits of a *Rosellinia* root infection. In Philip Field situated on the heavier Brasso Clay soil at the same estate, it was observed that the land was quite free from *Rosellinia* although certain portions of the fields were subject to periodic floodings. It thus appeared that some nice balance of soil moisture and texture was required before *Rosellinia* root disease could appear.

(3) Montana Estate.

Another diseased area of cacao investigated in Montserrat District in Field 2 on the above estate was of similar topography to Goodwa at La Vega being situated near the summit of a hill ridge. The cacao was interplanted with bananas and coffee, and bushes of the latter were also found killed by *R. Pepo*. The soil analysis of the diseased area F, is given in Table II.

Soil Texture. Can best be described as nondescript.

Hydrogen Ion Concentration. This is normally acid.

Organic Matter and Nitrogen. The organic matter is very high in comparison with previous samples. The C/N ratio is normal.

Available Potash and Phosphate. Available phosphate is extraordinarily low. Potash is low but not markedly so.

Rate of Nitrification. Production of nitrates is adequate.

Discussion.

The disease was observed to have spread from the plateau up the side of the ridge to the summit leaving a trail of dead and dying cacao trees in its wake. A similar interpretation to that put forward to explain the presence of the disease at La Vega is offered here. (*See* Fig. 2.) The spread of the disease from the plateau is interpreted in the light of increased conditions of moisture which obtain in this field due to its elevation and the presence of bananas which helped to maintain humid conditions.

(4) Henry Estate.

The third case of a *Rosellinia* patch adjacent to a hill slope was encountered at McDougal Field in the above estate, situated on flat-lying land composed of light sandy soil. The annual rainfall in the area was from 60 to 80 inches. Ten trees which died as a result of infection by *R. Pepo* were treated by the complete eradication of the stumps. Only two trees were found with the fungus in an active state on the roots 5 years later. Both were near the base of McDougal Hill. The soil analysis of the diseased area G, is given in Table II.

Soil Texture. This is very sandy and is the lightest sample taken during this survey.

Hydrogen Ion Concentration. This is normally acid.

Organic Matter and Nitrogen. Organic matter and nitrogen are both fairly high and the C/N ratio about normal.

Available Potash and Phosphate. Phosphate supply is medium low whilst available potash is fairly high being the highest recorded of the Trinidad samples.

Discussion.

The importance of soil texture was again shown here since no disease was observed in Smart Field adjacent to this site which differed only in the heavier nature of the soil.

Grenada: Annandale Estate.

A classical example of a *Rosellinia* patch was found in Ross Field, 50 years old, situated on a steep hill slope at an elevation of 1,200 feet on boulder strewn red soil with an annual rainfall

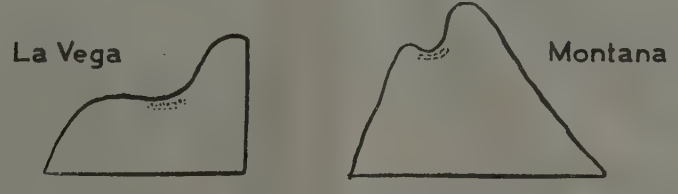

Fig. 2.—Showing relation of *Rosellinia* patch to topography.

of over 120 inches. Cacao, nutmeg, and avocado pear trees were all found attacked but bananas and tannias observed growing lower down on the hill-side were free from disease. A view of the patch is shown in Fig. 4. In the background is the ground provisions garden, the presence of which in old cacao plantations suggests previous sites of *Rosellinia* patches which the planter finding unprofitable had turned to other uses. Analysis of soil from diseased, H, and healthy, I, areas is given in Table II.

Soil Texture. This is the heaviest soil found in the survey. The diseased area contains a heavier clay than the healthy.

Hydrogen Ion Concentration. There is no significant difference between the two areas.

Organic Matter and Nitrogen. The amount of organic matter is very much greater in the diseased area but that in the healthy area exceeds any of the records from Trinidad. The amount of nitrogen shows a corresponding increase and is extremely high in the diseased area. The C/N ratio is more than adequate in both areas.

Available Potash and Phosphate. The available potash is very high in both areas and is higher in the healthy area. Phosphates are low but the amounts do not differ significantly in the two areas.

Discussion.

The clayey nature of the soil and the comparatively high level of organic matter, nitrogen and C/N ratio marks this *Rosellinia* patch unique in comparison with the Trinidad examples. The disease picture closely approaches the traditional concept where conditions which best suit the host are best suited to the parasite, although in this instance the marked deficiency in potash coupled with the acidic reaction places this field in the poorer category of cacao yielding soils.

Summary of Field Observations.

No marked trends in Hydrogen Ion Concentration, amount of Nitrogen, Organic Matter, available Potash and Phosphate and rate of Nitrification could be observed to play any part in defining the limits of patches of cacao attacked by *R. Pepo,* in the random samples selected for analysis. The one factor common to all the *Rosellinia* patches was a deficiency in available Phosphate (below 40 p.p.m.). There was some evidence however that Soil Texture when considered in relation to topography and Soil Moisture might prove of some significance. The persistence of *R. Pepo* on cacao in sandy or well drained soil has apparently only been previously recorded by Howard (14).

III.—Experimental Work.

Isolations of *R. Pepo* were made and the fungus studied in pure culture as well as in controlled inoculation experiments to establish proof of pathogenicity and to determine if possible under what range of conditions the fungus behaved as a parasite.

Isolation and Cultural Characteristics.

R. Pepo was isolated from diseased roots of cacao in Trinidad (Fig. 7) and Grenada and from nutmeg in Grenada. All three cultures were indistinguishable. Cultures of *R. bunodes* for comparison were isolated from *Hibiscus rosa-sinensis* (Fig. 8) and grapefruit from Grenada and arrowroot from St. Vincent. *R. Pepo* was readily isolated from diseased cacao roots by separating the "bark" from the wood and inoculating Dox's and 2 per cent. Dextrose-Potato media with small pieces of tissue bearing the white mycelial fans. The ease with which *R. Pepo* was isolated and the lack of other associated organisms strongly suggested that the fungus was a primary parasite. No case of *Sphaerostilbe repens* in association with *R. Pepo* was seen on cacao or nutmeg roots as was recorded by Briton-Jones (4) on limes.

The fungus was cultured on a variety of media, when it was found that growth was best on natural media and poorest on synthetic media. Three types of mycelial growth were observed similar to the types described by Nattrass (20) for *R. necatrix :* (i) "exploration hyphae"—a very diffuse white mycelium composed of fine attenuated hyphae ; (ii) mycelial fans (Fig. 5), greenish-grey to white in colour, growing out from food bases ; and (iii) mycelial strands of rhizomorphs, white at first and later becoming black with a white core, varying in length from 5 to 15 millimetres. These were only formed in the host tissues or below the surface of media containing carbohydrates (Fig. 6). Growth on various media was as follows:—

(1) *Two per cent. Malt Agar.* Growth at room temperature (25–28° C.) at first white. After 3 days the centre becomes green tinged and a faint zonation appears in plate cultures. By the sixth day dark brown striae have appeared and three zoned rings formed. After 14 days the culture presents a dark brown shiny appearance with a white margin and is covered with a light aerial growth closely applied to the surface of the medium in the form of a flattened mycelial fan. Fresh isolations sometimes develop abundant dark olive green aerial mycelium (Fig. 7). Mycelial strands of rhizomorphs are not produced abundantly on this medium. They appear within 3 weeks and are white at first, then black with a white centre. The coremial stage is only produced on this medium after 4–5 months.

(2) *Ten per cent. Malt Agar.* Growth is slower than on 2 per cent. Malt Agar, aerial growth denser with more marked zonation, becoming dark brown. The initiation of the coremial stage becomes apparent after 10–14 days in the darker green zones. Black rhizomorphs with a white centre are formed abundantly within 14 days.

(3) *Two per cent. Dextrose-Potato Agar.* Growth was slower, dark brown in colour and with less aerial mycelium than in 2 per cent. Malt Agar. Black mycelial strands were produced in 3 weeks (Fig. 6). A sterile coremial stage developed after 3 months.

(4) *Dox's Agar.* Growth was slow, submerged, and dark brown in colour with little aerial development of mycelium. The coremial stage appeared on the inoculum when this was composed of 2 per cent. Malt Agar or pieces of diseased root material and produced conidia after 50 days.

(5) *Mixed Media.* Following the observations on the production of the coremial stage on the 2 per cent. Malt Agar inoculum on Dox's Agar, growth on mixed media was tried (Fig. 9). A glass ring was placed in the centre of a Petri dish and the whole sterilised. The ring was then filled with 2 per cent. Malt Agar and when this had set, the outside space was filled with Dox's Agar. Inoculation was made at the centre of the dish. The coremial stage was produced abundantly after a period of 40 days on the Dox's Agar just outside the glass ring. In one plate they were produced on the malt inside the ring. The production of conidia was well developed in 50 days.

(6) *Sterilised Potato Plugs.* Growth on Irish Potato plugs was slow, a dense mass of compact purplish-black hyphae being formed after 3 weeks with no coremial stage. On sweet potato plugs a dark brown to black growth was obtained, the coremial stage was well developed and produced conidia. Mycelial strands were formed inside the plug and grew out into the moist cotton wool at the bottom of the culture tube.

(7) *Sterilised Cacao Material.* The fungus grew readily on sterilised Cacao branches, ½" in diameter. After 17 days the initiation of the coremial stage was observed in cracks in the drier parts of the bark and on the cut ends. Examination of an inoculated root fragment after 4 weeks showed the presence of white lines under the bark. These developed into typical white strands 10 weeks after inoculation (Fig. 10). The fungus also grew into the cotton wool plug at the base of the tube with the formation of "black lines" (Fig. 11).

Effect of Temperature on Rate of Growth.

The rate of growth of the fungus was measured by obtaining the mean of five plates of 2 per cent. Malt Agar under standardised conditions. Growth was inhibited at temperatures of 7.2° C. and 33° C. When removed from these ranges only one out of five cultures held at 33° C. for 5 days resumed growth at room temperature. On the other hand, all the plates held at 7.2° C. for 14 days retained their viability and resumed growth at room temperature. The fungus grew best at a temperature ranging between 25° C. and 27° C., with an average rate of growth per day of 0.5 centimetres at 25° C.

Effect of pH on Growth.

The effect of the Hydrogen Ion Concentration on the growth of the fungus was studied on broad lines only. Three series of plates of 3 per cent. Bacto Nutrient Agar with the pH adjusted to 4.5, 6.3 and 8.5 respectively were inoculated. No differences in the rate of growth were found in the three series. *R. Pepo* would thus appear to be tolerant of a wide range in pH which is confirmed by field observations.

Inoculation Experiments.

The pathogenicity of *R. Pepo* was proved by inoculation experiments with Forastero cacao seedlings growing in unsterilized soil, sand and on agar media under aseptic conditions (Fig. 12). In the latter case the seeds germinated within 14–21 days from sowing in Erlenmeyer flasks of 2 per cent. Dextrose-Potato agar. The seedlings were inoculated when 3 weeks old and wilting and death took place within 14 days, the normal period of infection for plants growing in soil and sand. Infection originated at the collar of the hypocotyl from the region of one of the lateral roots. Small, white mycelial stars, characteristic of this fungus, were formed between the stele and outer cortex, and rhizomorphic strands were very abundant in the host tissues and in the media. Cacao seedlings have been grown for 6–8 weeks in flasks containing either 2 per cent. Dextrose-Potato Agar, 2 per cent. Malt Agar or Knudson's Solution B Agar, inoculated with species of *Penicillium* and *Mucor,* and have still remained healthy while seedlings in flasks inoculated with *R. Pepo* all died within 2 weeks.

Attempts to produce infection of young cacao seedlings at the region of the collar by inoculation with a suspension of conidia produced by the coremial stage were negative. No success was obtained in attempts to germinate the conidia in hanging drops of sterile water, 1 per cent. and 2 per cent. Malt Extract. Hansen *et al.* (13) report similar failure in germinating conidia produced by *R. necatrix.*

Rate of Infection and Soil Moisture.

An attempt was made to determine experimentally the part played by soil moisture in predisposing the parasitism of cacao seedlings by *R. Pepo.* Similar experiments were performed by Toovey (30) using *Hibiscus* cuttings in soil taken from a *Rosellinia* patch area at River Estate and employing pieces of naturally infected cacao roots as a source of inoculum. His results, although inconclusive, suggested that the optimum soil moisture limit for *R. Pepo* to function as an active parasite was about 53 per cent. saturation or lower for this particular soil type, since all his cuttings grown in soil maintained at this level succumbed to infection. An upper limit was found at approximately 76 per cent saturation where only one cutting was killed by *R. Pepo* during a period of 3 months. He concluded that the fungus was intolerant of excessive soil moisture and suggested that it was very sensitive to soil aeration and that there might be some correlation between soil texture and the distribution of the disease in cacao soils.

The writer in confirming Toovey's work found that portions of cacao root infected with *R. Pepo* proved unsatisfactory as a source of inoculum since uniform viability could not be depended upon. Pure cultures of *R. Pepo* on sweet potato, 14 days old were substituted instead. Forastero cacao seedlings, 14 days old were planted in pairs in tin cans, 6″ × 6″ containing unsterilized soil from the same source employed by Toovey. Three different soil moisture series were established namely, 85 per cent., 65 per cent. and 35 per cent. saturation which were maintained at constant weight by the periodic addition of water. The tins in each series were inoculated with two slices of sweet potato cultures placed vertically 3 centimetres from the seedling root systems. The following results were obtained over a period of 35 days and are summarised in Table III.

Table III.

RATE OF CACAO SEEDLING INFECTION BY *R. Pepo* IN RIVER ESTATE SOIL AT VARYING MOISTURE AND 25 °C.

Days from Inoculation.	Soil Moisture % Saturation		
	85	65	35
5	—	—	—
10	—	10	9
15	—	2	3
20	3	1	—
25	1	—	—
30	—	—	—
35	2	—	—
Total Deaths	6	13	12

Infection of seedlings was slower in the series containing 85 per cent. moisture than in the two drier ones. The first seedling wilted 16 days after the date of inoculation and only 6 out of 16 of the seedlings died from attack by *R. Pepo*, during the period of observation. The rate of infection in the two remaining series was far more rapid, the majority of the seedlings succumbing to infection in 10 to 15 days. This was prior to any signs of infection in the wettest series. In the 65 per cent. saturation series, 13 out of 16 seedlings were killed compared with 12 out of 16 in the 35 per cent. saturation series. *R. Pepo* was re-isolated from dead seedlings in all series. Freedom from infection in any series was traced to failure of the fungus to establish contact with the host. In no instance did microscopic examination reveal any association between fungus and host in the roots of the plants remaining healthy. The greater incidence of the disease in the drier soil series was found correlated with greater quantities of the fungus which filled the air spaces with dense masses of woolly mycelium after the fashion observed in worm burrows in the field, whilst little evidence of mycelium activity was observed in the wettest series. The experiment confirmed the observations of Toovey (30) who found a greater mortality among his *Hibiscus* cuttings caused by *R. Pepo* in the series of low moisture content.

RATE OF INFECTION AND AVAILABLE SOIL FERTILITY.

Experiments to test the effect of the lack of the major essential elements (N.P.K. & Ca.) on the physiology of parasitism of *R. Pepo* on cacao seedlings grown in sand culture had to be abandoned 14 days after seed germination owing to the number of deaths caused by the fungus, which amounted to over 50 per cent. in all series. The conclusion reached was similar to that by Toovey (30) namely that the available chemical fertility plays no part in determining the course of infection. This conclusion is further supported by field observations.

INOCULATION EXPERIMENTS IN THE FIELD.

A successful inoculation experiment was performed in February on a cacao tree in Field 7a at River Estate, in an area where normally no *Rosellinia* is found. Two large roots were carefully excavated to avoid injury and covered for a length of 18 inches with one month old cultures of *R. Pepo* on oatmeal agar. The inoculum was covered with damp cotton wool before replacing the soil. No further moisture was added in this experiment which was carried out during the dry season. Inspection three months later revealed that successful penetration had taken place resulting in typical root rot with the formation of white mycelial stars below the bark.

IV.—Discussion of Results and Control Measures.

The evidence submitted leaves little doubt that *R. Pepo* is a primary parasite of cacao. Observations in both the field and the laboratory have shown that whenever contact between the parasite and the host, in an undamaged and healthy state is established, a parasitic invasion has followed, regardless of whether the host has been in the seedling stage or as a mature tree.

A study of the general distribution of the fungus in Trinidad and Grenada does not reveal any limitation due to climatic factors. Records of parasitism have been obtained from estates situated from near sea level up to over 1,200 feet with an annual rainfall which varied from 60 to over 200 inches. With regard to soil texture, the disease was most commonly observed slowly persisting in light sandy soils and rarely on heavy clays. The rate of spread of the *Rosellinia* patches in sandy regions of low rainfall was so slow in some instances that an impression of natural control was obtained. Laurent (15) records a similar state of affairs in the case of *R. necatrix* on the vine, which when present in wet soils

produces a root rot that usually results in a relatively rapid death of the stock whilst on lighter and drier soils the lethal issue of the attack may be delayed for several years, ending with the sudden collapse of the dead stock. The writer was not able to determine whether the soil moisture content of the cacao field could be reduced to the point where host and parasite might exist in the same habitat without a parasitic relationship being established, although such a belief was expressed by Briant (3) in the case of *R. bunodes* attacking arrowroot and shared by Briton-Jones (5).

The chief objectives in the control measures advocated in the past may be summed up as ventilation and the reduction of soil moisture and surface litter as described by Matz (18), Nowell (24), Tunstall (32), Petch (25) and Gadd (11). The localisation of centres of infection by means of isolation trenches and the eradication of diseased root stumps which act as food bases, recommended by Fawcett (6), Nowell (23), Negretti (21), Tucker (31) and Bally (1) appear justified where the area is small and the results obtained are commensurate with the cost of the operations and the value of the crop. The writer saw several instances of successful control of outbreaks of *R. Pepo* on cacao and nutmeg in Trinidad and Grenada, where a timely and thorough application of the principles of orchard sanitation had prevented further outbreaks of the disease.

On the other hand cases were met as at Annandale Estate, Grenada, where *R. Pepo* was found at a depth of over 4 feet on the main root of a cacao tree. Under these conditions the use of shallow isolation trenches is clearly impractical, and eradication work on the boulder strewn soil would not only prove difficult but costly. The abandonment of this area to more resistant ground provision crops capable of rotation appeared a logical solution to the problem.

Whilst no differences in soil pH could be correlated with patches of *R. Pepo* in cacao, Bally (2) has recorded *R. bunodes* attacking tea and coffee in soils having a low exchange acidity and has suggested the use of sulphur to correct this. Other workers have applied sulphur, copper sulphate, calcium hypochlorite, chloropicrin, and lime as "disinfectants" but the writer feels that the value of these chemicals should be proved commensurate with their cost and effectiveness before being recommended.

The success attendant on the use of tree surgical methods, so strongly advocated by Nowell (24) where the elimination of the diseased root also removes the source of infection emphasises the importance of the fungus in the disease complex. This fact together with the evidence submitted in this paper supports the current view summarised by Garrett (12) that *R. Pepo* is a soil inhabitant whose parasitism is incidental to its saprophytic existence.

An important problem which has a bearing on the outbreaks of the disease and which still remains to be investigated in the West Indies is the determination of the nature of host resistance and the part played by susceptible shade trees in the initiation of root disease in the plantation crop. Gadd (8, 9) has shown that the carbohydrate supply of tea roots influences the type of fungi found attacking them, those usually deficient in starch reserve being associated with species of *Botryodiplodia* and *Rhizoctonia* whilst those showing a normal starch reserve are infected with *Rosellinia* among other genera. Leach (16, 17) in some original experiments has shown that the carbohydrate supply in shade tree roots profoundly affects the incidence of *Armillaria mellea* on the stumps when the trees are felled. If the carbohydrate supply is depleted by ring-barking some time before felling, the root system becomes invaded by saprophytes of the *Botryodiplodia* type which are harmless to the plantation crop, to the exclusion of the parasitic *Armillaria* which is unable to become established under these conditions. Walters (33) in advising the replacement of the very susceptible shade tree "Immortelle", *Erythrina* sp., by the highly resistant *Glyricidia* observed that *Rosellinia* root disease becomes prominent in the cacao as the shade trees are removed and accordingly recommends a gradual shade reduction by heavy pruning. The effect of this pruning on the carbohydrate supply in the roots of the shade tree and the resulting influence if any, on the incidence of *Rosellinia* appear to be well worth further study in the light of Leach's investigations.

V.—Summary.

1. An account is given of attempts made to gauge the factors in both field and laboratory, which control the physiology of parasitism of *Rosellinia Pepo* Pat.

2. An analysis of soil within and adjacent to *Rosellinia* patches showed no relation between hydrogen ion concentration, amount of nitrogen, organic matter, available potash and phosphate and the incidence of the disease.

3. The disease was most frequently observed in Trinidad persisting in soils of light texture and this is stressed of some significance in relation to the study of the water relationships of the soil.

4. It was established in experiments conducted to test the relation between soil moisture and disease incidence that the rate of infection of cacao seedlings was most rapid in the drier and better aerated series.

5. It was not determined whether soil moisture could be reduced to the level where host and parasite might exist together without a parasitic relationship being established.

6. The necessity for further work on the nature of host resistance especially in relation to carbohydrate supply in the light of recent work is stressed.

VI.—Acknowledgments.

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SPECIES OF CARPET GRASS.

Mr. R. B. Jagoe in *The Gardens' Bulletin, Straits Settlements* Vol. XI Part 2, describes and illustrates the two distinct species of carpet grass in Malaya. He summarizes the chief distinguishing features as follows :—

Axonopus compressus Beauv. (Savannah grass).	*Axonopus affinis* Chase. (Carpet grass).
Leaves.—Broad, hairy, frequently with red colouration.	Narrower, stiff, folded, more or less glabrous.
Nodes.—Very hairy.	Hardly hairy.
Spikelets.—Long and pointed.	Blunt or short pointed.
Anthers.—Yellow with narrow purple outer edges.	Purple, with translucent dots.
Stigmas.—White.	Mauve.

A. affinis withstands dry weather better than *A. compressus* and is capable of covering the soil better in dry exposed situations. On poor, unshaded soil, in this country, the former species frequently grows by densely-leafy, short internoded stolons, and it is probable that it will, in time, largely predominate in such conditions.

Under medium shade, however, where both make their best growth, *A. compressus* appears to have a distinct advantage.

There is some slight confusion as to palatability and value of carpet grass as pasture, but this is probably due to the previous confusion of two species with but one name.

There is no doubt that the true *A. compressus* Beauv. is a good pasture grass, being recognized as such in tropical America and Australia. It appears equally true that *A. affinis* has a variable reputation. It is definitely regarded as inferior in Australia, and chemical analyses quoted by McLennan clearly show it to be inferior, as fodder, to *A. compressus*.

In Malaya, a few years ago, *A. affinis* appeared to be liable to cause purging of cattle, due to slight increase in hydrocyanic acid content if cut at too freqeunt intervals. The author has, however, seen *A. affinis*, under light shade, grazed by cattle with relish, and obviously in preference to *Paspalum conjugatum*. — (*Malayan Agricultural Journal*, XXIX, 1, 1941.)

THE SOILS OF INDIA.*

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The soils of India offer a distinct contrast to those of many other countries in that they are very old, fully mature, and do not show generally the pedogenic processes and the close relationship between the soil and its rocky substratum. The weathered materials in most cases have been transported to great distances by various agencies. The great majority of soils are of ancient *alluvial origin,* and the so-called Indo-Gangetic Alluvium comprises almost the entire portion of extra-peninsular India occupying the greater part of Sind, Northern Rajputana, the Punjab, the United Provinces, Bihar, Bengal and Assam. This area may again be divided into three main divisions, namely, the Indus Alluvium, the Gangetic Alluvium and the Brahmaputra Alluvium. These may again be divided into Sub-mountain and Plains regions. These alluvia were originally derived from the rocks of the Himalayan Range of mountains.

The peninsular of India represents an ancient table-land, a large area of which is covered by the ancient and the earliest-formed gneisses and schists. The series of rocks known as Dharwar Series are considered to be the upper and younger members of the Archaean rocks. On the weathered and denuded edges of the Dharwar rocks, and associated with gneissic rocks, occur a series of thick sedimentary formations (Cuddupah), and a thin series called the Karnool Formation. Similar formations lying on folded Dharwar beds occur in the Vindhyan system of rocks of the Aravalli Hills. A colossal volcanic eruption sometime after the Vindhyan epoch, brought the Deccan Trap Rock into being.

The examination of the soils derived from these varied geological forms of rocks has shown that, although the nature and composition of the soils reflect to some extent the composition of the original rocks from which they are derived, the main trend of weathering and its final results are influenced to a considerable extent by climate, particularly by the amount and the seasonal distribution of rainfall. In India, the unique monsoonic division of the year into dry and wet periods, and the high temperatures that prevail, considerably influence the character and the sub-aerial denudation of the surface of the country. Compared with the soils of the Temperate Zone, the aerial and soil temperatures in India are higher by as much as 10 to 20 degrees Centigrade or more, and therefore all chemical reactions involved in the soil and plant processes proceed many times more rapidly. The high temperatures and humidity function so intensively that chemical decomposition follows almost at the heels of rock disintegration, and is the more conspicuous feature of the soil processes in the plains. The result is that, irrespective of the nature of the original rocks from which the soils are derived, the forward reactions of normal weathering and the secondary reactions resulting from the shifting equilibrium on the basis of solubility and interactions have tended towards the direction dictated by the climate of the locality.

It would thus appear that a system of soil classification based on climate as the predominant function assumes a particular significance in connection with the practical aspects of soil utilisation and land development in India. In assessing the relationship between soil and its climate (temperature, precipitation and evaporation), neither the rain factor proposed by Lang, nor Meyer's N-S quotient (which is obtained by dividing the value for precipitation by the value for saturation deficit) is entirely satisfactory. An additional factor, the degree of wetness, is being investigated. Meanwhile, a division has been made into four broad groups, beginning with arid in the west, and passing eastward through semi-arid and humid into per-humid zones.

(1). The *Soils of the Arid Zone* are characterised by high base saturation, and both calcium and sodium are in excess over magnesium and potassium. About 80 per cent. of the silica is in the soluble form. The soils are pink in colour, due probably to their being residues of syenitic rocks, and, by interaction with colloidal silicic acid which is not removed owing to scanty rainfall, a thin coating of iron oxide is formed on the silica particles. The silica-sesquioxide ratio of 2.91, and kaolinisation, are indications of maturity.

(2), (3). The *Soils formed under Semi-Arid and Soils formed under Humid conditions* are developed from almost all types of rock systems, and are either brown, black or red. It would appear from the analytical data that the soils are not always residues which have survived weathering, but in many cases, are adsorption complexes of iron oxides and silicic acid. Those derived from limestones are richer in lime content but more alkaline, as for example, the soil from Surat developed from *Nummulites*, and that of Tabiji which is derived from limestones. These soils developed under semi-arid and humid conditions contain proportionately greater amounts of silicic acid consequent on the removal of the bases of the alkali and alkaline earth metals. Base-saturation of the silica is lower than in the case of arid soils.

(4). *Soils developed under per-humid conditions* show distinctly the effects of leaching action. During development, these soils acquire colours

* Abridged from Scientific Reports of the Imperial Agricultural Research Institute, New Delhi, for year ending 30th June, 1939 (pp. 84-88.)

Table I.—Average Molecular Composition and Ratios of Clay from Soils Classified on the Basis of Colour.

Soil Colour.	Combined SiO_2.	Fe_2O_3.	Al_2O_3.	CaO.	MgO.	K_2O.	Na_2O.	Combined $\frac{SiO_2}{R_2O_3}$.	Combined $\frac{SiO_2}{Fe_2O_3}$.	Combined $\frac{SiO_2}{Al_2O_3}$.	Combined $\frac{SiO_2}{Bases}$.
Black	0.752	0.069	0.225	0.035	0.066	0.017	0.035	2.59	11.31	3.39	1.69
Brown	0.650	0.068	0.239	0.023	0.026	0.023	0.035	2.15	9.83	2.78	1.62
Red	0.579	0.073	0.256	0.008	0.020	0.016	0.018	1.66	8.38	2.09	1.42
Pink	0.615	0.060	0.211	0.051	0.062	0.040	0.065	2.28	10.44	2.93	1.27

depending on the prevailing local conditions of climate and source of origin. Agronomically, black and red soils are distinguished, and are invested with specific agricultural qualities. The *black soils* (which are different from peaty and other forest soils rich in organic matter and from the black soils of swamps) are highly siliceous, and the clays contain high amounts of alkalies and alkaline earth bases. A variety of rock systems under semi-arid and semi-humid conditions give rise to these soils. The high silica-alumina ratio (3.39) shows that they are highly kaolinitic and have adsorbed alkalies to a great extent. The *red soils* (which are also derived from the same rocks as black soils) have clays with low lime content. The molecular composition of the clay fractions from soils and also the total iron content of whole soils, on the basis of colour classification, are shown in Tables I and II.

Table II.

Total Iron Content of Soils.

Soil-Type.	Maximum per cent.	Minimum per cent.	Mean.	Number of samples.
Indo-Gangetic alluvium ...	7.60	2.30	4.8	12
Brown alluvium —South India	17.30	4.84	8.8	6
Black soils ...	11.50	4.34	7.1	18
Red soils ...	7.10	3.50	5.5	7
Laterite (so called) ...	48.71	6.12	19.2	8
Red soils of hills ...	11.91	9.08	10.1	6

On the basis of the concentration of water-soluble salts and their depth-distribution in the profile, five main soil groups may be differentiated, namely :—(1) Profiles in which the concentration of soluble salts is highest at the surface and lowest at the bottom (*i.e.* 5 feet), (2) profiles in which the highest salt concentration is at the surface and the lowest somewhere in the middle of the profile, (3) profiles in which the highest salt concentration occurs somewhere in the middle, while the lowest concentration is either at the surface or at the bottom, (4) profiles in which salt concentration is highest at the bottom and lowest either at the surface or somewhere in the middle, and (5) profiles with concentration more or less uniform throughout and the total quantities very low.

In the profiles of the *first* group, sodium and and chlorine predominate, while in the *second* the sulphate radicle is either very low or absent. The *third* group is charactised by the predominance of either calcium or sodium and sulphate or chloride. The *fourth* group is characterised by very high salt concentration, while the *fifth* contains very low amount of salts.

The profiles of the uncultivated soils in places of low and medium rainfall do not show much variation in the depth distribution of exchangeable bases. In the arid and semi-arid regions, calcium constitutes 70 to 80 per cent. of the total exchangeable bases, while magnesium, potassium and sodium together vary between 5 and 15 per cent. In humid and perhumid regions, the exchangeable calcium is lower at the surface than in the deeper layers.

The total exchange capacities of the surface soils, considered in terms of climatic classification and colour classification are given below in milli-equivalents per 100 grams of soil.

Table III.

Basic Exchange Capacities.

Arid	10.5 mg. Eq. %
Semi-arid	30.0 ,,
Humid	31.3 ,,
Per-humid	13.7 ,,
Black soils	52.8 ,,
Brown soils	23.3 ,,
Red soils	13.5 ,,
Pink soils (largely of the Indo-Gangetic alluvia) ...	8.0 ,,

When, however, the values are calculated to exchange capacity in milli-equivalents per 100 grm. of clay, on the assumption that the exchange capacity resides entirely in the clay fraction of the soil, the large differences shown in Table III vanish, as revealed in Table IV.

Table IV.

BASE EXCHANGE CAPACITY OF CLAY FRACTIONS.

Arid	64.3 mg. Eq. %
Semi-arid	72.8 ,,
Humid	74.3 ,,
Per-humid	84.3 ,,
Black soils	84.3 ,,
Brown soils	105.2 ,,
Red soils	58.2 ,,
Pink soils (Indo-Gangetic alluvia)	62.4 ,,

Usually 50 to 100 milli-equivalents per cent. are accepted as the range for the base-exchange capacity of mineral colloids, and the results are within these limits in all the types of soils examined. But the results obtained so far do not indicate that base-exchange capacity is positively correlated with the clay content. The black soils contain the largest amount of clay, but do not appear to possess the highest efficiency in base-exchange capacity. This is presumably due to the secondary reactions under the influence of climatic factors.

The data so far available on the carbon and nitrogen contents of the profiles show that the ratio of carbon to nitrogen in the surface soils varies from 5.1 to 23.6, though in several cases it is about 10.0. The wide ratios are noticeable more particularly in a belt of soils which exhibit weak nitrifying ability as judged by comparative nitrification studies in the laboratory. The ratios do not show any striking feature in the various depths in the profile. Considering the carbon-nitrogen ratios in respect to soil and climate, it would be expected that the nitrogen content of the soil would be a function of the mean annual temperature and humidity, and would decrease exponentially with increasing temperature. Such a relationship has been extended to organic carbon also. When, however, the available data for surface soils are plotted on the map at the places from which the soils were collected they appear to fall into three distinct regions; those with ratios between 12 to 20 fall in one region, with ratios 10 to 12 fall in another region, while those with values below 10 form a separate region.

EFFECT OF DERRIS AND OTHER INSECTICIDES ON MAN AND ANIMALS.

According to an article by R. D. G. Th. Simons in the *Bergcultures*, 14, pp. 808-810, 1940, various investigators have come to the conclusion that the toxic properties of derris are not solely due to the rotenone but also to other constituents. Fish are killed or paralyzed by crushed derris root thrown on the water. Insects are affected in various ways. For some species it is a case of delayed action; caterpillars, however, are very sensitive; derris is deadly to animal fleas but the human flea is little affected. Flies, mosquitoes and their larvae are fairly resistant, while some beetles even feed on it in storage. Warm-blooded animals such as cats, mice and guinea pigs, if they eat or are injected with extract of derris root, are strongly affected, apparently in the central nervous system, and die of suffocation. Experiments on goldfish by the author gave the following results:—derris powder sprinkled on the water of an aquarium killed the fish in six minutes. The concentration was 1 : 300 or in terms of rotenone 1 : 4,000. Rotenone alone in the same concentration worked less quickly. Rotenone-free ether extract acted more quickly than rotenone. Pyrethrum had the effect of quickly "paralyzing" the fish. Of these four materials only derris powder and pyrethrin had any inflammatory effect on the eyes of guinea pigs.

The effect on humans is described. Taken in the mouth, derris powder produces a numbing sensation extending to the throat, the power of taste disappears and in some cases causes headache. A healthy man can stand 80 mg. of rotenone while a man in poor health would be seriously inconvenienced by it. Workers in derris factories generally complain of lassitude, loss of taste, oppression in the chest, burning sensations in the mouth and throat, and headache. Other sensitive parts of the body are also affected but after a time a certain degree of immunity seems to be acquired. The author notes that for himself a few hours without a respirator in a derris factory is sufficient to cause nausea. Little is really known of the use of derris in medicine, *i.e.* in ointments and soap, and there is no evidence that it is an improvement on materials at present used, whereas it can often be a cause of eczema.

A number of proprietary insecticides having a petroleum or carbon tetrachloride base, to which are added such substances as coal tar, citronella oil, pyrethrum extract, nicotine, &c., are briefly discussed. It is concluded that vapour from these preparations was toxic to insects. Mosquitoes were killed in ten minutes. Smoke from pyrethrin and tobacco was effective in small sealed rooms but any draught at once disposed of the value of tobacco smoke. Contact with these preparations killed mosquitoes immediately but the tougher cockroach took ten minutes to pass out. As far as the practical use of these preparations is concerned it seems that only direct contact is really effective. Their repellent value is small and, applied to the skin, *e.g.* against mosquito attack, they are fairly ineffective and if used frequently may cause injury.

CHEMICAL NOTES.

(Compiled by the College Department of Chemistry and Soil Science.)

Excavation of Growing Trees with Earth.

For purely horticultural purposes it is often required to remove trees and shrubs with a ball of earth for transference elsewhere, and considerable care and ingenuity must be exercised if success is to be achieved. Mr. F. A. F. Schmid and Mr. F. J. Nutman, of the East African Agricultural Research Station, Amani, Tanganyika Territory have described (*Soil Science*, 49, No. 6) a method devised by them during research on the water relations of coffee, for which they required large plants several years in age which could only be obtained in the field. The authors state that by their method a growing tree together with about two tons of soil has been successfully transplanted, and that only the outbreak of war has prevented further excavations. There appears, it is said, to be no limit to the size of the soil block that can be isolated in this fashion save only the size of the vehicle available for transport.

Their work was done in a district with a very light, friable, volcanic ash soil, with few stones. It is admitted that the presence of stones might make this method difficult if not impossible. The apparatus required is simple. The method consists of the preparation, by mechanical means, of an accurately cone-shaped pillar of soil, of a known and definite angle, of the fitting to this pillar of a metal container designed to have the same angle, and of the undercutting and removal of the soil block. Since the container fits the block exactly, and since the lift is *via* the sides, the authors state, of the cone-shaped receptacle, no soil disturbance is possible. The paper, with diagrams, explains the method in full.—(*Nature*, 147, No. 3737; 1941.)

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Reinau Test for Soil Fertility.

This test has been devised by Dr. E. H. Reinau of Berlin. He has for several years been interested in problems of *soil respiration*, and presumably the test is a development of his activities in this field. The test consists essentially in plotting the curve of temperature after a soil has been mixed with a basal dressing of cane-sugar, with or without small quantities of inorganic substances. Sugar is added in amount supposed to correspond to the organic matter in 400 centners of farmyard manure per hectare, and the nitrogen, phosphate, and potash are added singly or in suitable combinations at rates corresponding to about 10 centners of commercial fertilizer per hectare. The test is conducted as follows. Soil is divided into eight portions, each of 125 cubic centimetres. Each is put in a vacuum flask provided with a thermometer. To each portion, 675 mg. of sugar are added. One portion receives no further addition and serves as control, another receives 7.5 mg. of nitrogen (presumably as ammonium sulphate), the third the same amount of nitrogen and 3.8 mg. of K_2O, a fourth the same amount of nitrogen and 2.2 mg. of P_2O_5. Other combinations are similarly made. The sugar and salts are dissolved beforehand in the correct amount of water to bring the soil to an optimal water content. The eight flasks are placed in a thermostat, and the temperature of each flask is read at about four or six-hourly intervals continuously for 48 hours.

The shape of the curve is supposed to indicate the response to additions of N, and to P and/or K, in presence of N. Since the shape of the control curves of good and poor soils is different, it is claimed that the test can be an indication of fertility, as distinct from nutrient response. The theory underlying the test is obscure, but it is supposed that the bacterial activity of soils is variously stimulated by the addition of sugar alone, or in conjunction with N, P, or K, and that this bacterial activity expresses itself by varying degrees of heat evolution. In the two papers available (*Tech. Landw.*, 19, 1938: 69/74; *Chem. Ztg.* 63, 1939: 63/65), no data have been found correlating the results of the test with yields of crops in the field, but curves are given showing typical responses for all eight treatments on a "good" and a "poor" soil. It is not clear therefore, how far the test does indicate actual responses, though it may be capable of application for this purpose and holds interesting possibilities. The method is simple and seems adapted to routine performance.—(H. Nicol in *Chronica Botanica*, VI, 11 (1941), p. 252.)

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Coconut Poonac as Manure.

There are several grades of coconut poonac in Ceylon. Sediment poonac may contain up to 70 per cent. nitrogen while the other grades, except chekku poonac which has less, contain about 3 per cent. Sediment poonac, in spite of its high oil content (about 20 per cent.) has a narrow C/N ratio (8.46) and could be considered a manure as good as groundnut cake. The oil itself is unlikely to have any deleterious effect on the soil for recent work has shown that, contrary to general belief, fats are readily oxidized in tropical soils and provide considerable energy for nitrogen fixation. Poonac also contains about 3 per cent. potash and 1.5 per cent phosphoric acid. When manure firms are unable to supply the full requirements of nitrogen in inorganic form 50 per cent. of the nitrogen is replaced by groundnut cake. It is calculated that it would not be uneconomic to use coconut poonac instead of groundnut cake in coconut manure mixtures and that provided there are no technical objections its use as manure may be encouraged.—(See *Trop. Agriculturist*, 1940, **95**: 3-7.)